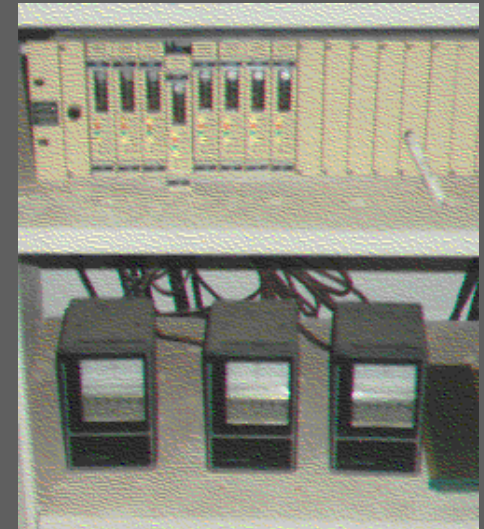




# Continuous Gas Monitoring

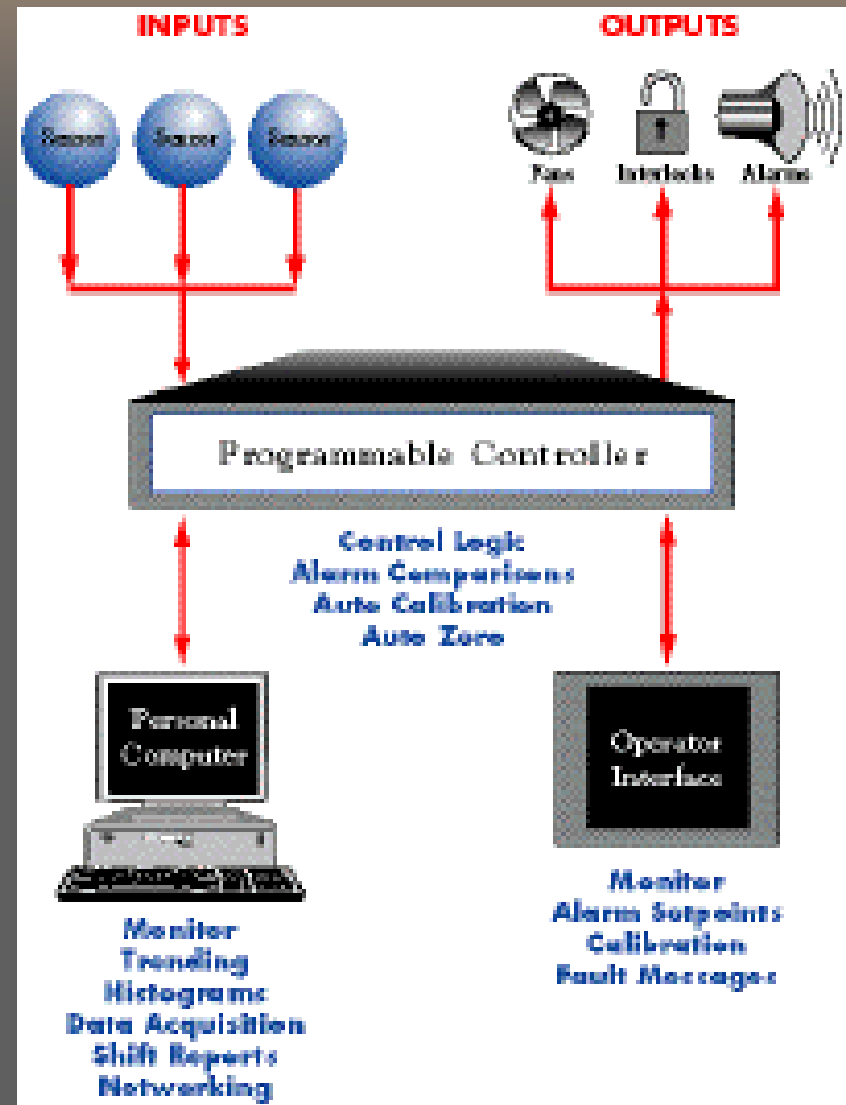
Glenn K. Young, P.E.

Senior Waste Management Engineer



# Overview

- ⇒ Background
- ⇒ Regulations
- ⇒ System Overview
- ⇒ Components & Cost
- ⇒ System Installation/  
Operation & Maintenance
- ⇒ Implementation
- ⇒ Summary



# Background

- Postclosure Land Use/Residential & Commercial Development of former disposal sites
- Safety regulations (OSHA) drive industrial requirements for monitoring hazardous conditions (Petroleum and natural gas industry), which drove sensor technology development
- Development of Direct Digital Control (Automatic) technology in 1980s to monitor and control building and utility systems for energy conservation
- Combustible gas monitoring applied in industrial settings for safety purposes
- Combustible gas monitoring applied in residential and commercial settings due to 27 CCR Landfill Gas Monitoring and Control requirements and Brownfield and industrial development





# Gas Measures at PCLU projects



# Regulations

- ➔ Federal Regulations (40 CFR Part 258.23) Explosive Gas Control
- ➔ State Regulations (27 CCR Article 6)
- ➔ 27 CCR Gas Monitoring & Control Regulations
  - 20919.5 (a) 1 Explosive Gas Control.
  - 20921 Gas M&C During Closure/PC
  - 20931 Structure Monitoring
  - 20934 Reporting
  - 20937 Control
  - 21190 Postclosure Land Use

# Regulations

- ➔ 27 CCR 20919.5 (a) 1 Explosive Gas Control "...owners...must ensure that: (1) The concentration of methane gas generated by a (MSWLF) facility does not exceed 25 percent of the LEL for methane in facility structures..."
- ➔ 20921 (a) (1) requires that "...The concentration of methane gas must not exceed 1.25% by volume in air within on-site structures..."
- ➔ 20931(a) "...monitoring network design shall include provisions for monitoring on site structures, including but not limited to buildings, subsurface vaults, utilities or other areas where potential gas buildup would be of concern..."

# Regulations

- ⇒ 20931(c) "...Structures located on top the waste disposal area shall be monitored on a continuous basis.."
- ⇒ 20934 (a)(1) "...monitoring reports shall include: (1) the concentrations of the methane....within each on-site structure..."
- ⇒ 20937 (a)(3) "...the documentation of date, time, barometric pressure, atmospheric pressure, general weather conditions and probe pressures..."

# Regulations

- ⇒ 20937 Control (d) "...When the results of monitoring in on site structures indicate levels in excess of those specified in Section 20923(a), the operator shall take appropriate action to mitigate the effects of landfill gas accumulation in on site structures, and public health and safety, shall include one or more of the following:...(4) Alarms, ...(5) Ignition source control...(7) Ventilation..."



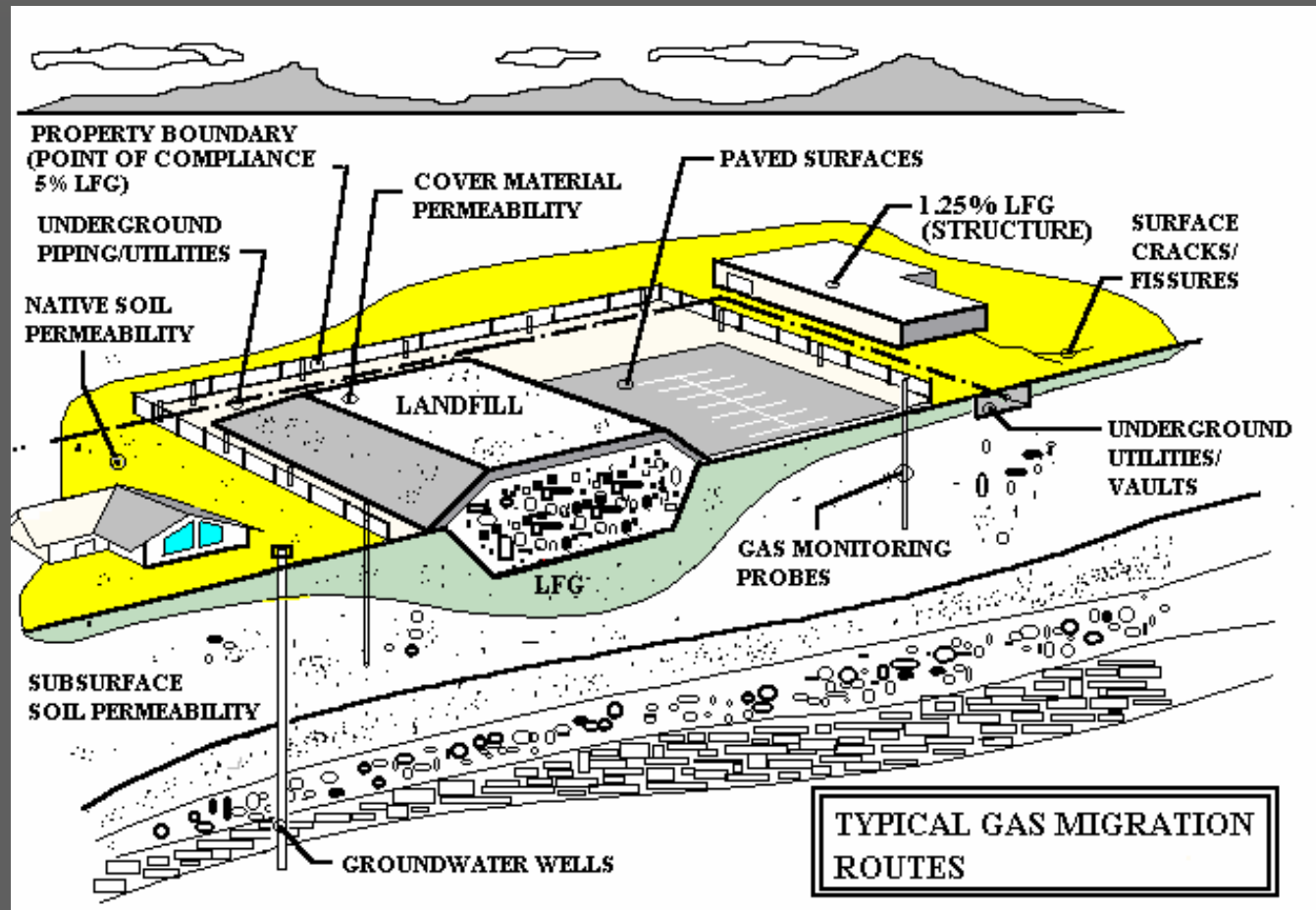
# Regulations

- ⇒ 27 CCR 21190 a) Proposed PCLUs shall be designed and maintained to: ... (3) prevent landfill gas explosions...
- ⇒ 27 CCR 21190 e) "...Construction of structural improvements on top of landfilled areas...shall meet the following conditions:...(1) automatic methane gas sensors, designed to trigger an audible alarm when methane concentrations are detected, shall be installed in all buildings..."
- ⇒ 27 CCR 21190 e) (8) periodic methane gas monitoring shall be conducted inside all buildings...

# System Overview

- ⇒ Landfill Gas Migration Routes
- ⇒ Sensor Locations
- ⇒ Continuous Gas Monitoring System
- ⇒ HVAC Control Interface

# Landfill Gas Migration Routes



# Gas Migration Routes





# Gas Migration Paths

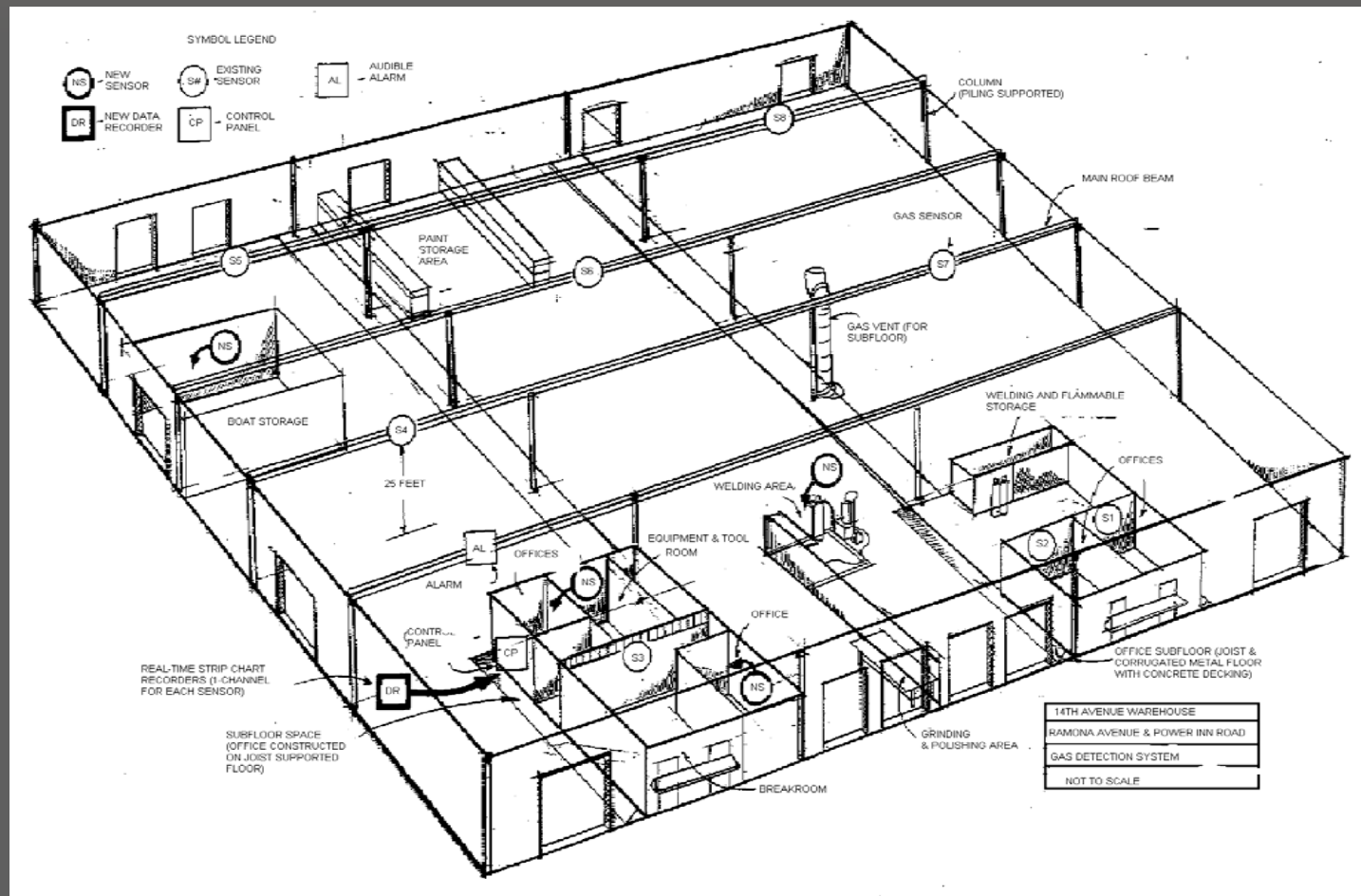




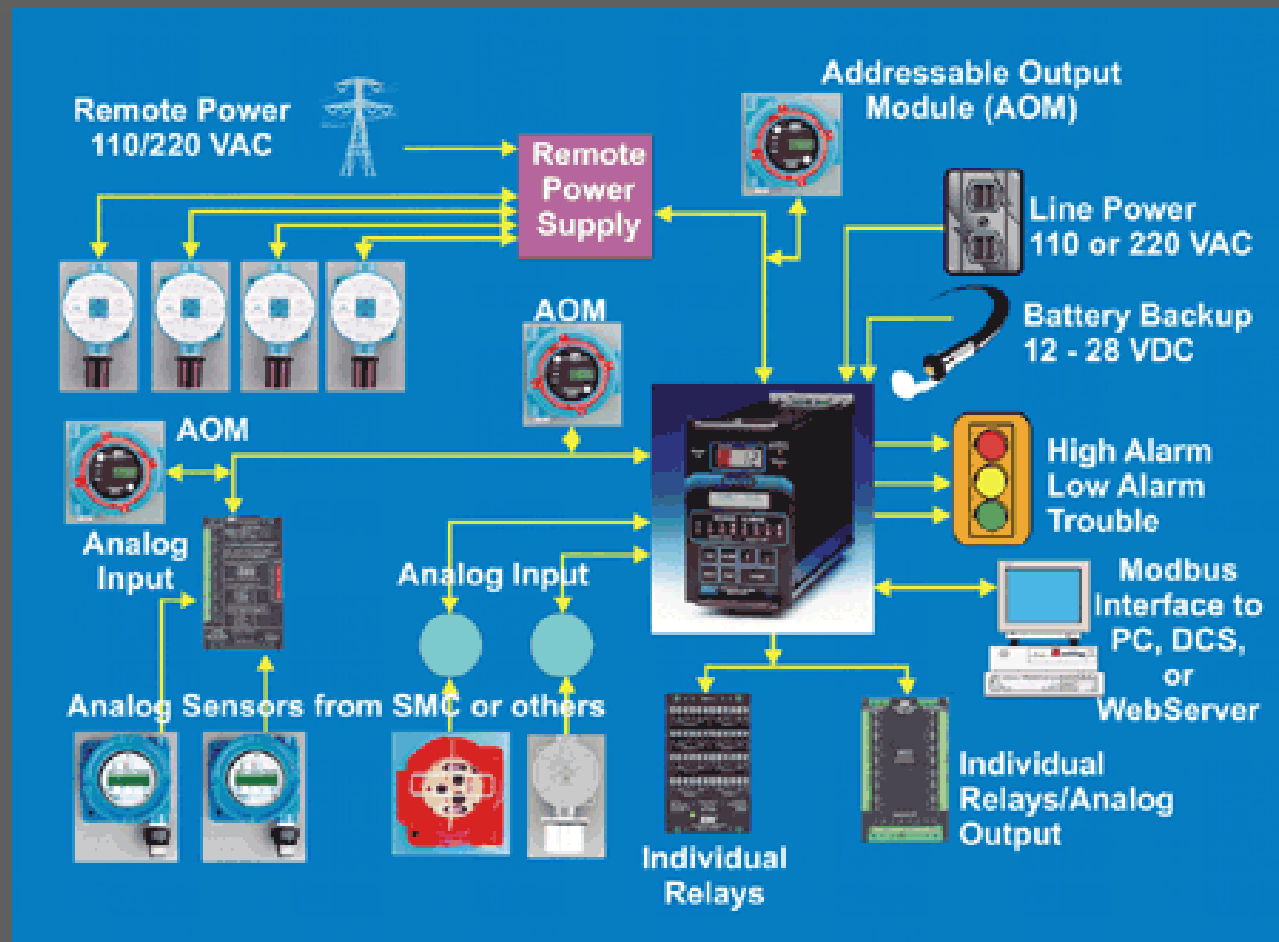
# Gas Sensor Placement

- ➔ Any accessible confined spaces near a landfill where a 5-15% LEL-UEL condition would most likely occur
- ➔ Structures on or within 1000 feet of the landfill (homes, buildings, warehouses, etc)
- ➔ Basements, subfloors and raised foundations
- ➔ Utility systems: manholes, vaults, boxes and subsurface trenches, storm drains, water & electrical distribution in the vicinity or through the disposal area
- ➔ Utility closets, mechanical rooms, bathrooms (utility penetrations)
- ➔ Water wells, excavations (pools)

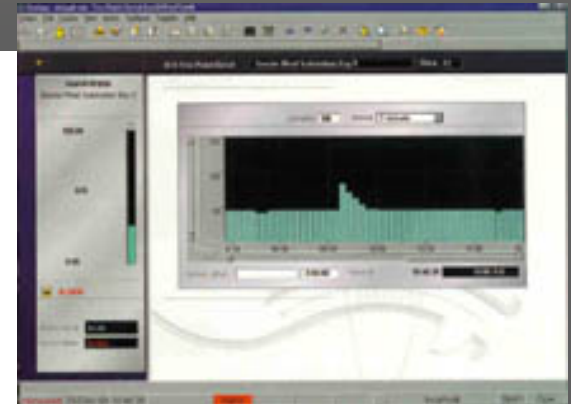
# Gas Sensor Placement



# Continuous Gas Monitoring System



# Bldg Monitoring & Control Systems



# Components & Costs

- ➔ Sensors
- ➔ Controller
- ➔ Data Loggers
- ➔ PC-interface



**Gas Sensor**



**Controller**



**PC-Interface**

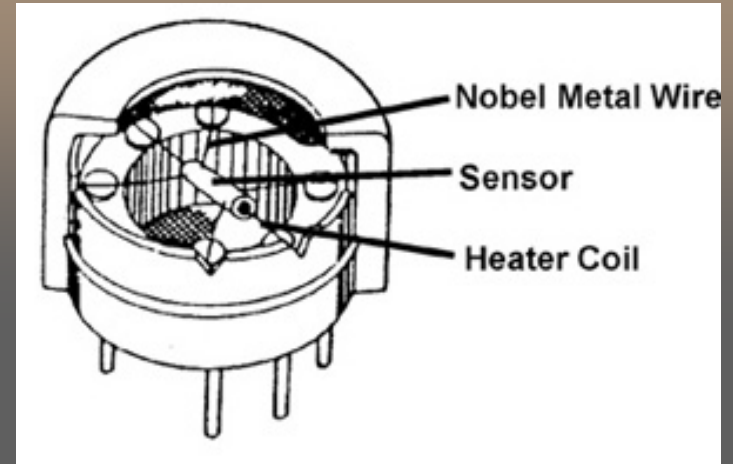


**Data Logger**



# Gas Sensors

- ➔ Detects presence and measures concentrations of combustible gas
- ➔ Generally CGI instruments calibrated to "known" gas (methane)
- ➔ Catalytic Bead or Infrared (IR) Sensor
- ➔ IR sensors do not require oxygen
- ➔ Explosion Proof Housing
- ➔ 24 VDC Power to Sensor/Transmitter
- ➔ 4-20 mA Analog Output Signal
- ➔ Wall mounted NEMA 4X Enclosure
- ➔ Wireless models available
- ➔ Cost: \$300-\$1500/sensor



# Gas Sensors (CG/LEL)



**Scott  
GasPlus-IR**



**RKI PS-2  
Single Point  
(\$425)**



**GDS M-1**



**Biosystems  
GasChek1 (\$2295)**



**Safe T Net Model  
128 1-Ch**

# Gas Sensors (CG/LEL)



**BW Gas Point Sensor**



**RKI Eclipse Sensor  
Catalytic  
(\$550)**



**Biosystems  
GasChek/Catalytic  
Bead/EXP (\$995)**



**RKI S-Series  
Catalytic**

# Controllers

- ➔ Controller used to “receive” 4-20 mA sensor (transmitter) analog output signal, store in data acquisition unit (if present), and control “output” devices such as alarms, electric switches, solenoid valves or other “controls”, e.g. turn-on heating, ventilation and air conditioning system (HVAC)
- ➔ Controllers are microprocessor based and programmable (but require software and a PC interface).
- ➔ Controllers require power source (120V/60-hz)
- ➔ Controllers are wall-mounted in weatherproof NEMA 4X enclosures
- ➔ Controllers can be single or multichannel (typical: 4, 8, 10, 16, 32 and up (cost increases); for a typical closed disposal site with commercial or residential structures a 16-channel should suffice
- ➔ Controllers generally cost between \$500-\$3500

# Controllers



**RKI BL-7000  
16-Ch**



**PEMTECH  
PT-1008 8-Ch**



**GMI Active 8  
8-Ch**



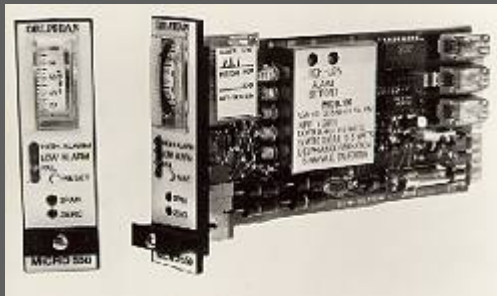
**RKI Beacon 800  
8-Ch (\$1995)**



# Controllers



SMC Sentry 8-ch



Gas Tech 1-Ch



BW CR-8700 8-Ch



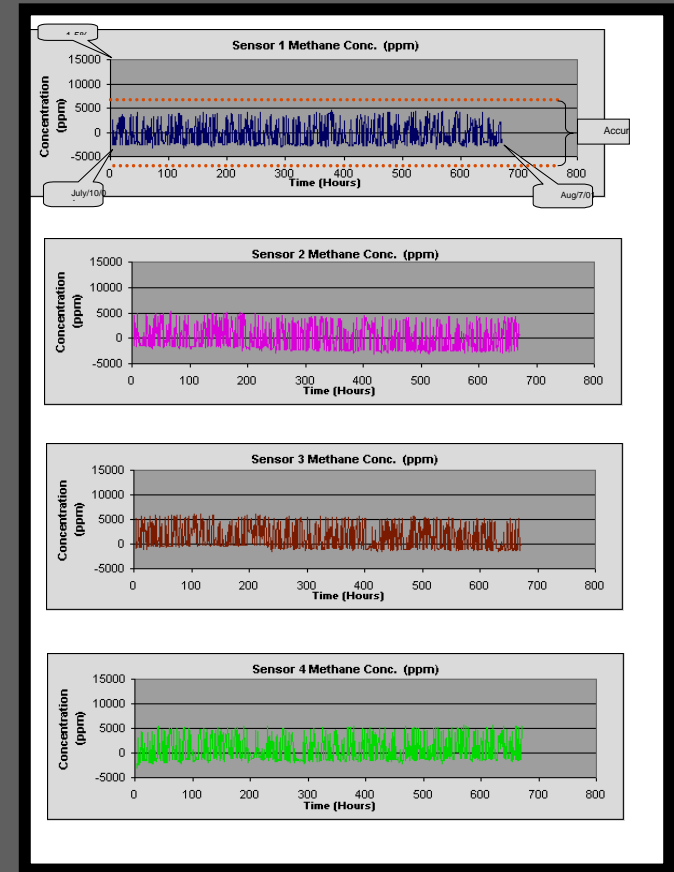
ANTX 40-Ch



CR-9600  
96 Channels

# Data Loggers (Data Acquisition)

- ➔ Loggers provide memory to store data points produced by 4-20 mA measurements (gas concentration measurement normally 0 to 5%  $V_{gas}/V_{air}$ ) taken by gas sensor
- ➔ Loggers can be programmed to query and store data at user defined timepoints and frequencies, e.g. 1 measurement per hour, 24 hrs per day, 7 days per week, 365 days per year.
- ➔ Logger programs can output data to spreadsheets for documentation and data analysis, e.g. graphical representation (measurement versus time) for time trend analysis
- ➔ Provides documentation and defensible evidence for determining 1.25% in structures and 5% at the perimeter boundary.



# Data Loggers (Data Acquisition)

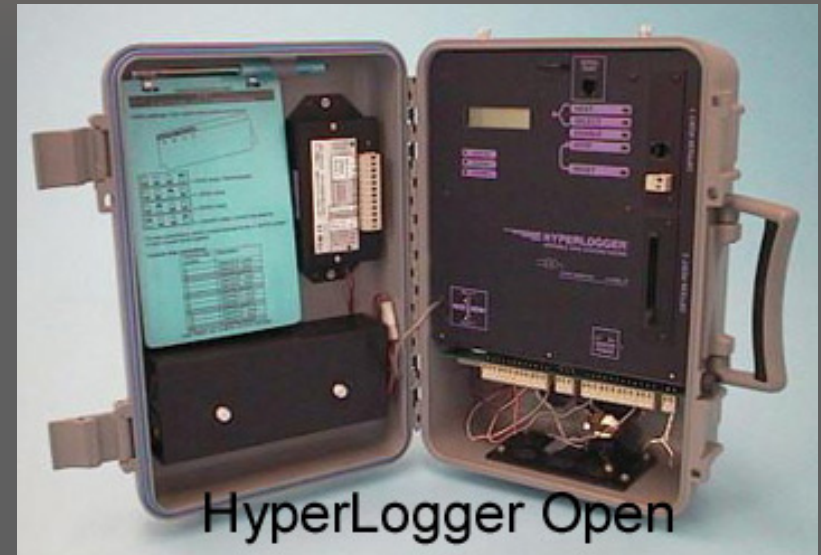
- ➔ Manufacturers: Logic Beach, Omni Instruments, DataQ, HOBO, WebDAQ, Yokogawa, MadgeTech
- ➔ Data Logger may require: software for PC interface, additional memory, modem, wireless transmitter (these are not included in base unit cost)
- ➔ Data Logger requires power (120V or 24V source), phone line connection
- ➔ Data Loggers with multichannel capability, PC interface software, memory and modem can run between \$1500 and \$3500
- ➔ See The Data Logger Store: <http://www.microdaq.com/>

# Loggers (Data Acquisition Units)

DataQ DI-710 (\$1400)



Logic Beach HyperLogger (\$3000)



WebDAQ 100 (\$1295)



Omni DAQ 4000 Logger  
(695 British Pounds)

# System Installation

- ➔ Power source (120 V/60 Hz) required to operate data logger, controller, sensor and PC interface (if on-site); power consumption is nominal; Battery back-up required
- ➔ Standard telephone connection (modular jack) required to data logger for remote data access and downloading
- ➔ Sensor should not be placed in a corrosive environment or subject to irrigation waters, although designed for outdoor use
- ➔ Sensors can be used in constructed “probe vaults” to simulate utility boxes
- ➔ Wireless systems should be used if feasible to minimize installation costs
  - Ensure receivers and transmitters are “line-of-site” without obstructions
  - Locate antennas as high as possible in structures
  - Purchase and use signal repeaters if signals are weak
- ➔ For systems where “hard-wiring” is used:
  - Cable runs should consider subsurface utilities and landscaping (cost increases with burying cable in areas with pavement, landscape and utilities)
  - Conduit may be considered for cables in common areas or potentially subject to traffic or vandalism; 12 inch direct burial of cable is acceptable (per NEC)
  - Cable runs need to meet voltage drop requirements based on length of run and cable or wire size (generally 1000 feet or less for No. 12 AWG)
  - Sensor should be “clustered” if possible to minimize installation disturbance



# System Installation



# System Operation & Maintenance

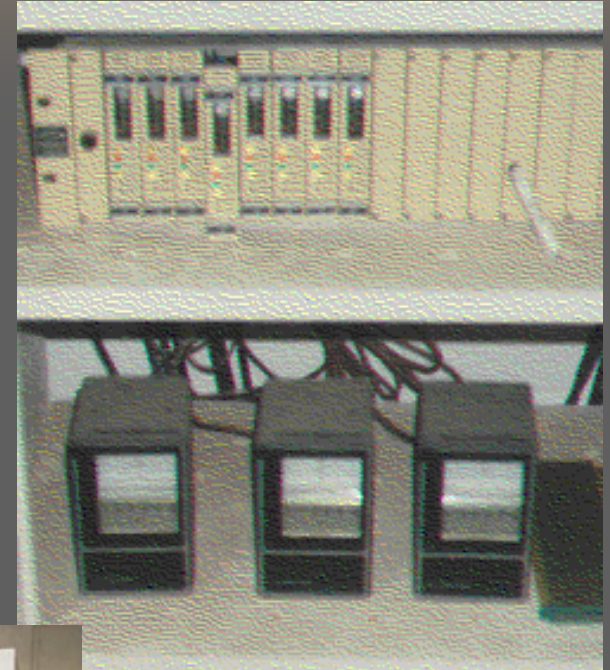
- ➔ System should be calibrated once per quarter or if erroneous readings are detected during monthly download
- ➔ System data should be downloaded monthly or as required based on memory size and data collection frequency (24-hr, 7-day, 365-day is typical)
- ➔ System requires a dedicated phone line and power supply (with separate circuit and breakers).
- ➔ Most systems come with back-up battery to maintain data; however power restoration is critical



**“Zero-Span” Calibration**



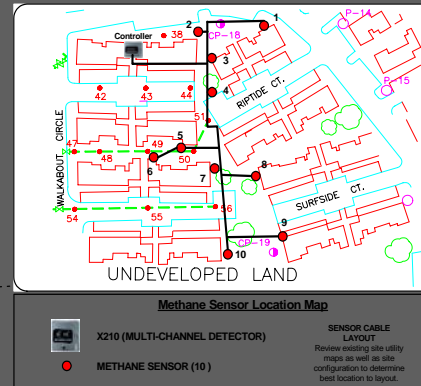
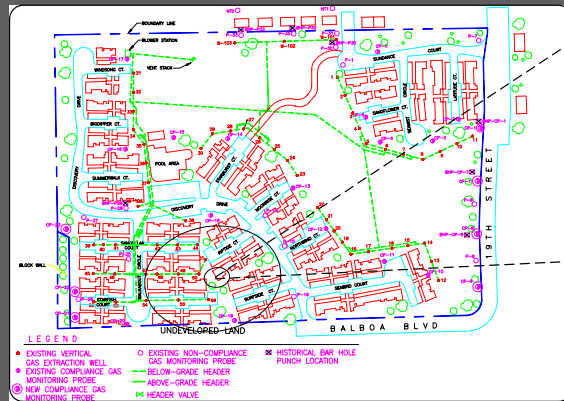
# System Operation & Maintenance



- ⇒ Drawings & Specifications
- ⇒ Consultants & Contractors
- ⇒ Equipment Manufacturers
- ⇒ Equipment Distributors

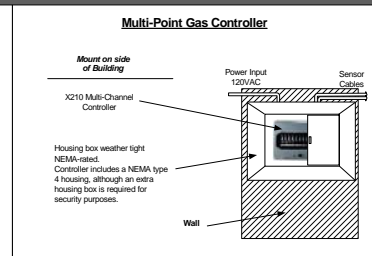
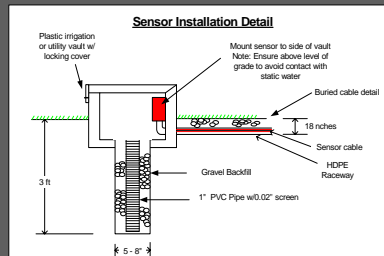


# Drawings & Specifications



## Notes:

1. Davis Instruments Multi-Channel Gas Detector Model X210 for 10 Channels, Catalog No. UP7901909, Operating Power 115V± 10VAC/ 220VAC 50/60Hz or 24 VDC.
2. X210 Dimensions: 24"Wx20"Hx8"D
3. Panel Box: NEMA type 4 panel enclosure (included), an extra housing box is needed for security purposes, weather tight NEMA-rated.
4. Cable Length: #22 or #20AWG Shield, 3 conductor cable, up to 3000 ft.
5. Sensors Required: Total of 10 Methane sensors, Model S21OR8
6. Sensor cables buried at minimum depth of 18" enclosed in HDPE conduit (please review site configuration to determine best location to bury the cables).
7. Drawing no to scale.



California Integrated Waste Management Board  
1001 I Street - Sacramento, CA 95814  
Permitting & Enforcement  
(Closed Regal & Abandoned Sites Investigation Unit)

Date: 06/26/2001

Prepared By: Glenn K. Young/Abel Martinez-Centeno

**Continuous Gas Monitoring System**  
Newport Terrace Condominiums



# Consultants & Contractors

- ⇒ SCS
- ⇒ BAS (Bryan A. Stirrat & Associates)
- ⇒ URS
- ⇒ TetraTech
- ⇒ Ninyo-Moore

# Equipment Manufacturers

- ATI [http://www.apisystemsgroup.com/products/fire\\_detection\\_systems.php](http://www.apisystemsgroup.com/products/fire_detection_systems.php)
- Biosystems <http://www.biosystems.com/>
- BW Technologies <http://www.gasmonitors.com/main.cfm?deploc=1&depid=1>
- Crowcon : <http://www.crowcon.com/>
- Det-Tronics <http://www.detronics.com/>
- Dräger [http://www.draeger.com/ST/internet/US/en/Products/Detection/StationaryGasDetection/stationary\\_gas\\_detection.jsp](http://www.draeger.com/ST/internet/US/en/Products/Detection/StationaryGasDetection/stationary_gas_detection.jsp)
- General Monitors <http://www.generalmonitors.com/>
- GDS Corp <http://www.gdscorp.com/>
- GMI <http://www.gmiuk.com/>
- Industrial Scientific <http://www.indsci.com/>
- LandTEC <http://www.ces-landtec.com/>
- Manning Systems <http://www.manningsystems.com/>
- MSA <http://www.msanet.com/catalog/catalog507.html>
- RAE Systems <http://www.raesystems.com/>
- RKI Instruments <http://www.rkiinstruments.com/>
- Scott Instruments <http://www.scottinstruments.com/>
- Sensidyne <http://www.sensidyne.com/>
- Sieger [http://www.gas-detection-equipment.co.uk/combustible\\_gas\\_sensor.htm](http://www.gas-detection-equipment.co.uk/combustible_gas_sensor.htm)
- Sierra Monitor Corp (SMC) <http://www.sierramonitor.com/>
- Thermo-GasTech <http://www.thermo.com/BURedirect/welcomeMsg/1,5107,73,00.html>
- ZellWeger

# Distributors

- ⇒ A-L Compressed Gases  
<http://www.alcompressedgases.com/>
- ⇒ Industrial Safety Equipment & Supplies  
<http://www.majorsafety.com/category.cfm?Category=17>
- ⇒ Jensen Instrument, Co.  
<http://www.jenseninstrument.com/Products.html>
- ⇒ Davis Instruments

# Summary

- ➔ Automated or Direct digital control systems have been in use for over 20 years and if properly calibrated and maintained are reliable, efficient and cost-effective
- ➔ Systems can provide time-trend gas monitoring data that is accurate and legally defensible (can be used to show 1.25% by volume in air levels for enforcement purposes)
- ➔ Difficult to demonstrate compliance with 1.25% rule
- ➔ In addition to monitoring, systems can be used to control alarms and ventilation, which would directly protect public health and safety
- ➔ System components (sensors, data acquisition systems, controllers, etc.) can be purchased off the shelf from numerous manufacturers

# Summary

- ➔ Cost of continuous gas monitoring system (<\$50K) is substantially less than typical landfill gas extraction and treatment systems (\$500K-\$1.5M), e.g. if project costs are to be prioritized the first remedy would be to implement a continuous monitoring system in structures to protect public health and safety. For example a wireless continuous monitoring system with 10 sensors would cost
  - 10 sensors @ \$1000/sensor or \$10K
  - 1 each 16-channel controller @ \$4500 or \$4.5K
  - 1 each data logger @ \$3000 or \$3.0K
  - 10 wireless transmitters and receiver @ \$5K
  - Design and Installation Cost \$10K
  - Total system cost: \$32.5K



# Summary

- ⇒ Continuous systems should be “designed”, specified and installed by a qualified and experience consultant and contractor
- ⇒ Continuous monitoring systems must be operated, calibrated and maintained to minimize the risk of gas migration into structures and protect public health and safety